Focused Session - Li-ion Battery Safety Incidents: Risk Assessment and Prevention

Why are internal cell shorts a concern?

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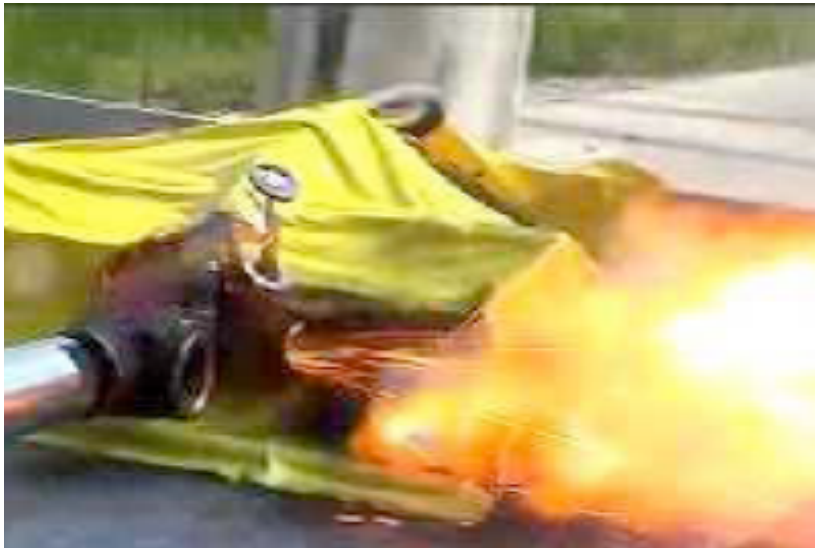
Why are Li-ion cell internal shorts a concern?

- **Li-ion cells provide the highest specific energy (>180 Wh/kg) and energy density (> 350 Wh/ L) rechargeable battery building block to date with the long life necessary for servicing many spacecraft**
- **Electrode/electrolyte thermal instability and flammability of the electrolyte of Li-ion cells make them prone to catastrophic thermal runaway under some rare internal cell short conditions.**
- **These incidents are estimated by some* at a 1 in 1-10 million probability with COTS cells in consumer applications**
  - Can we lower that probability?



•B. Barnett, et. al., Power Sources Conference, Philadelphia, July 2008
•C. Mikolajczak, et. al., IEEE Portable 2007 Conference, Orlando, 2007

CPSC Record of Relevant Field Failures

Date	Recall #	Description	Incidents qty	Injury qty	Recall qty
May-05	05-179	Apple iBook laptop batteries, LG Chem cells (Taiwan/China)	6	0	128,000
Jun-05	05-204	Hi-Capacity ® laptop batteries, China/Korea/Taiwan	6		10,000
Apr-06	06-145	HP Compaq laptop batteries, unknown cell	20	1	15,700
Aug-06	06-245	Apple Powerbook, Dell laptops, Sony cell (Japan)	9	0	1,800,000
Jul-07	07-267	Toshiba laptop batteries, Sony cell (Japan)	3	0	1,400
Oct-08	09-035	Dell, HP, Toshiba laptop batteries, Sony cell (Japan) made from 0ct 04 to Jun 05	19	2	100,000
		totals	63	3	2,055,100

All injuries were minor burns

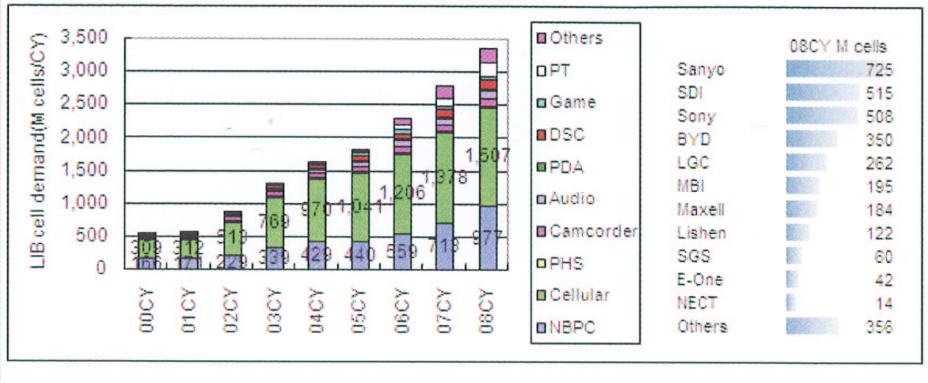
Above list contains only recalls since 2001 caused by cylindrical Li-ion cell issues

Total worldwide Li-ion cell demand from 2001 to 2008 was 14.5 billion cells*

Latest one (Oct 08) reported with cells made 4 years earlier and indicates a long latency.

- ~100 incidents since 2001
- ~10 billion cells since 2001

➡ 1 in 100 million probability



*Institute of Information Technology, Ltd

Questions to Ponder

- **What can the aerospace community do to reduce this risk?**
  - Assessment
    - How often have field failures been caused by internal cell shorts vs the quantity of units fielded?
    - How do you assess the risk on new cell designs with very few units fielded?
  - Mitigation
    - What cell design features are most effective for prevention of internal shorts?
    - What operational measures should be taken to reduce the probability of exercising a cell with a defect into an internal short?
    - What manufacturing practices are best for prevention and detection of cell defects?
    - What test screens should be applied to lots of cells and batteries to expose suspicious cell performance prior to fielding them?
    - How effective are each of these mitigations in reducing the probability of occurrence of cell internal shorts?

Li-ion Battery Safety Incidents: Risk Assessment and Prevention.

- **The focus is on internal cell shorts, particularly discussing design features that have merit in prevention and manufacturing and test screens that have merit in detecting defects and preventing field failures.**
  - Why Are Cell Internal Shorts a Concern? *E. Darcy*, NASA-JSC
  - NASA-JSC Method for Testing and Screening of Internal Shorts, *J. Jeevarajan*, NASA-JSC
  - Mechanisms of Latent Internal Cell Fault Formation and Opportunities for Detection, *C. Mikolajczak*, S.Stewart, J. Harmon, Q. Horn, K. White, and M. Wu, Exponent Failure Analysis Associates
  - Understanding Safety-Related Field Failure (not Abuse) of Lithium-Ion Batteries, *B. Barnett*, TIAX
  - Mitigating Cell Internal Shorts for the Spacesuit Li-ion Battery, *J. Newbauer*, ABSL, and E. Darcy, NASA-JSC
  - Lithium-ion Cell/Battery Design, Manufacturing, and Tests for Safe Operation, *R. Gitzendanner*, Lithion
  - Does Cell Screening Work? R. Staniewicz, SAFT
  - Safety Design Features of GS Yuasa's Large Lithium-ion Cell, *T. Inoue* and H. Yoshida, GS Yuasa
  - Open discussion